Welding Consumables and Proper Welding Conditions for

- Gas Metal Arc Welding (GMAW)
- Gas Tungsten Arc Welding (GTAW)

For Stainless Steel

Foreword

Note the following preliminary information on use of this welding handbook.

1. Standards for welding filler metals are abbreviated as follows

JIS : Japanese Industrial Standard
AWS : American Welding Society's Standard
EN : European Norm
ASME : American Society of Mechanical Engineers' Standard
DIN : Deutsches Institut Fur Normung
AISI : American Iron and Steel Institute
UNS : Unified Numbering System for Metals and Alloys

2. Classifications for welding filler metals are used in accordance with the following rules

Welding consumables are classified in accordance with basically the mechanical and/or chemical requirement of the standards, excluding such requirements as size, length, marking and identification manners. For derails please contect the nearest office or sales representative.

3. The test conditions of mechanical propeties and hardness are as follows

(1) Unless otherwise specified, impact are obtained with Charpy 2mm-V notch specimens.

(2) Unless otherwise specified, tension test and hardness test are carried out at room temperature.

(3) Unless otherwise specified, tension test and hardness test are carried out in the as-welded condition.

Abbreviations and marks with definitions

This welding handbook uses the following abbreviations and marks if necessary

Abbrev and mark	Definition
A	Ampere
Ar	Argon
C	Carbon
Cr	Chromium
DC-EN	DC, electrode negative
DC-EP	DC, electrode positive
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
J	joule (Impact Strength)
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Nb (Cb)	Niobium (Columbium)
Ni	Nickel
N/mm^2	newton per sq. millimeter
O_2	Oxygen Gas
P	Phosphorus
S	Sulfur
Si	Silicon
Se	Selenium
Ti	Titanium
V	Voltage
^{o} c	degree Celsius
NA	Not Applicable

Gas Metal Arc Welding and Gas Tungsten Arc Welding

A guide for selecting welding consumables

Stainless Steel type	Key note for application	Filler Metals	
		GMAW	GTAW
304	General	MS M-308	MS T-308
	Cryogenic temperatures	MS M-308L	MS T-308L
304L	Low carbon 0.04% max.	MS M-308LSi	MS T-308L
304N2	General	MS M-308N2	MS T-308N2
-	Dissimilar-metal joints	MS M-309	MS T-309
		MS M-309LSi	MS T-309L
316	General	MS M-316	MS T-316
	Cryogenic temperatures	MS M-316L	MS T-316L
316L	Low carbon 0.04% max.	MS M-316LSi	MS T-316L
317L	Low carbon 0.04% max.	MS M-317L	MS T-317L
347	General	MS M-347	MS T-347
347L	Low carbon	MS M-347L	MS T-347L
321	General	MS M-321	MS T-321
310	General	MS M-310	MS T-310
312	General	MS M-312	MS T-312
410	General	MS M-410	MS T-410
409,430,436,410L	Car exhaust system	MS M-430	MS T-430

Gas Metal Arc Welding and Gas Tungsten Arc Welding

Applications

1. Butt welding

Applicable plate thicknesses are 2 mm or larger with a 1.2 mm wire and 5 mm or larger with a 1.6 mm wire in flat position.

2. Horizontal fillet welding

Proper welding speeds are approximately 30-70 cm/min in horizontal fillet welding. With a 309 type wire, dissimilar-metal welding of stainless steel to carbon steel can be done in the same welding condition as used for welding stainless steels. However to secure the ferrite content of weld metal, welding currents should be 200A or lower and welding speeds should be 40 cm/min or slower with a 1.2 mm wire.

3. Overlaying and joining of clad steels:

The 1st layer of overlaying onto carbon steel should be welded with a 309 (or 309MoL) type wire by the half lapping method. In case where the dilution by the base metal is excessive, the ferrite content of the weld metal decreases and thereby hot cracking may occur. Therefore, it is important to use appropriate welding condition to control the dilution particularly for the first layer. In order to obtain the proper dilution ratio, welding currents should be 200A or lower and welding speeds should 20-40 cm/min with a 1.2mm wire. With a 1.6 mm wire, use welding currents in the 200-250A range and welding speeds in the 20-30cm/min range. Refer to Fig.1.

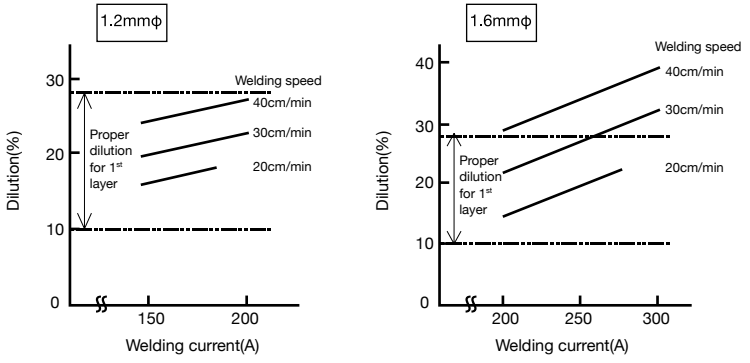


Fig.1 Dilution rations as a function of welding currents

Gas Metal Arc Welding and Gas Tungsten Arc Welding

GMAW

1. Polarity:

DC-EP is suitable.

2. Shielding gas:

98% Ar-2%O_2 mixture is recommended for general application. Proper gas flow rates range in 20-25 l/min. Ar-CO_2 mixture is not suitable for low carbon stainless steel (Type 304 L) because the carbon content of deposited metal increases.

3. Arc length:

GMAW of stainless steel generally uses the spray arc transfer mode due to lower spatter generation. Adjust arc voltage so that arc length becomes 4-6 mm When arc length is excessively short, blowholes are apt to occur. Inversely, When arc length is excessively long, the wetting of deposited metal on the base metal becomes poor.

4. Protection against wind:

GMAW is likely to be influenced by wind and there by blowholes may occur. Use a windscreen to protect the arcing area against wind when the wind velocity near the arc is 0.5 m/sec or more.

5. Pulsed arc welding:

In the pulsed arc welding, a stable spray arc can be obtained even with low welding currents. Pulsed arc is suitable for overlaying, welding of thin plates and vertical welding.

GTAW

1. Polarity:

DC-EN is suitable.

2. Shielding gas:

Argon gas is mainly used for shielding. Suitable flow rates of shielding gas are in the range of 7-15 l/min at 30-200A of welding current and 12-20 l/min at 100-300A in manual GTAW

3. Torch:

Two type of GTAW torches are available. One has a gas lens, another has no gas lens. A torch with a gas lens provides better shielding effect preventing the weld bead from oxidation since the gas lens can provide a regular gas flow.

4. Tungsten electrode extension:

Proper tungsten electrode extension are generally in the range of 4-5 mm. In the case where shielding effect tends to be lower as in welding corner joint, tungsten extension is recommended to be 2-3 mm. In welding of deep groove joints, tungsten extension should be longer as 5-6 mm.

5. Arc length:

Proper arc length are in the range of 1-3 mm. When it is excessively long, the shielding effect becomes poor.

6. One-side welding without backing materials:

In the case of one-side welding without backing material, adopt back shielding in order to prevent oxidization of the penetration bead.

7. Fully austenitic type filler wires:

With a fully austenitic type filler wire (e.g.,MS T-310), use lower welding currents and welding speeds to prevent hot cracking.

Warning and Caution in welding

Pay your attention to the following warnings and cautions for your safety and health during welding ad related operations.

 **WARNING**	Be sure to follow safety practices stated in the following in order to protect weldders, operators and accompanied workers from a serious accident resulting in injury or death.

• Be sure to follow safety pratices stated in the following when you use welding consumables.

• Be sure to follow safety practices stated in the instruction manual of welding equipment when you use it.

 **WARNING**	Electric shock can kill

• Do not touch live electrical parts

• Wear dry, insulated gloves. Do not wear torn or wet groves. Use an electric shock preventing device (e.g., open-circuit-voltage-reducing device) when welders or operators work in confined or high-level spaces. Use also a lifeline when welders or operators conduct welding at a high-level.

• Follow safety practices stated in the instruction manual of welding machines before use. Do not use a welding machine the case or cover of which is removed. Welding cables must have an adequate size for the capacity expected. Welding cables must be kept in an appropriate condition and a damaged cable must be repaired or replaced with new one.

Warning and Caution in welding

Pay your attention to the following warnings and cautions for your safety and health during welding and related operations.

CAUTION 	Fumes and gases generated during welding are dangerous to your health. Welding in confined spaces is dangerous because it can be a cause to suffocation by oxygen deficient.

• Keep your head out of the source of fumes or gases to prevent you from directly breathing high density fumes or gases.

• Use local exhaust ventilation, or wear respirators in order to prevent you from breathing fumes and toxic gases which cause toxication, poor health and suffocation by oxygen deficient.

• Use general ventilation during welding in a work shop. Particulary during welding in confined spaces, be sure to use adequate ventilation or respirators, and welding should be done at the presence of a trained supervisor.

• Do not conduct welding at where degreasing, solvent cleaning, spraying, or painting operations are carried out nearby. Welding work accompanied by these operations may cause generation of harmful gases.

• Use adequate ventilation or respirators with special attention during welding plated and coated steels.

• Use respirators, eye safety glasses and safety leather gloves during welding at all time.

Warning and Caution in welding

Pay your attention to the following and cautions for your safety and health during welding and related operations.

CAUTION 	Arc rays can injure eyes and burn skin.

• Wear hand shields with an adequate shade grade during welding operations and supervising the welding work. Select the correct shade grade for filter lenses and filter plates suitable for exact welding work by refering the standard JIS T81 41.

• Wear suitable protectors for protecting you from an arc ray; e.g., safety leather glove for welding, long sleeve shirt, foot cover, leather apron.

• Use, at need, shade curtains for welding by surrounding the welding areas in order to prevent accompanied workers from arc rays.

Pay your attention to the following warnings and cautions for your safety and health during welding ad related operations.

CAUTION 	Fire and explosion can take place.

Warning and Caution in welding

• Never conduct welding at areas adjacent to highly inflammable materials. Remove conbustibles so that splatters can not ignite them. If combustibles can not be removed, cover them with a noninflammable material.

• Do not weld vessels or pipes which contain combustibles or being sealed.

• Do not put a hot weldment close to combustibles right after welding finished.

• When welding ceilings, floors, walls, remove combustibles put at the order side of them.

• Any part of a welding wire, with exception of the potion appropriately extened from the tips of the torch, must be free from touching the electrical circute of the base metal side.

• Fasten cable joints and seal them with an insulation tape. The cable of the base metal side should be connected as close as possible to the welding portion of the work.

• Prepare fire-extinguishing equipment at where welding is carried out, in order to cope with a possible accident.

 **CAUTION** 	Flying spatter and slag can injure eyes and cause skin burns. High temperature heat of welding can cause skin burns.

• Wear safety glasses, safety leather gloves for welding, long sleeve shirts, foot covers, leather apron, etc.

• Do not touch weldments while they are hot.

Warning and Caution in welding

Pay your attention to the following warnings and cautions for your safety and health during welding ad related operations.

CAUTION 	The tip of a welding wire and filler wire can injure eyes, faces, etc.

• When take off the tip of a wire fastened in the spool, be sure to hold the tip of the wire.

• When check the wire feeding condition, do not direct the welding torch to your face.

CAUTION 	Falling down or dropping welding consumables can injure you.

• Wear safety shoes and pay your attention not to drop welding consumables on your body when carrying and handling them. Keepyourself in a correct posture not to cause a crick in your back while handling them.

• Follow the handling instructions shown on the surface of the pail pack wire packages when handle them.

• Pile up welding consumables in a correct way so as not to cause falling or dropping while they are stored or carried.

Gas Metal Arc Welding and Gas Tungsten Arc Welding

Ferrite content measuring methods for austenitic stainless steel weld metal

Method	Principle of measuring ferrite contain
Ferrite indicator:	Comparing the magnetic attraction between a standard ferrite percent insert and test specimen
Ferrite Scope:	Measuring a change of magnetic induction affected by the ferrite content of a test specimen
Magne Gage:	Measuring the pull off force necessary to detach a standard permanent magnet from a test specimen
Structure Diagram:	Calculating Ni equivalent and Cr equivalent of the chemical composition of a test specimen and reading the crossing point of the two equivalents in a structure diagram. Three structure diagrams are available: Schaeffler diagram, Delong diagram and WRC diagram. See Figs. 2,3 and4.
Point counting:	Calculating the area percentage of ferrite in the microstructure of a test specimen, by using an optical microscope

Fig.2 Schaeffler Diagram

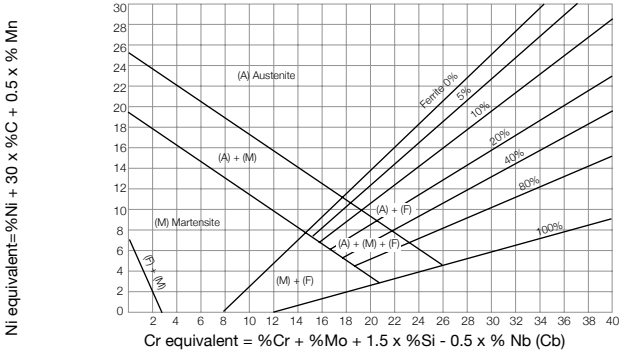


Fig.3 Delong Diagram

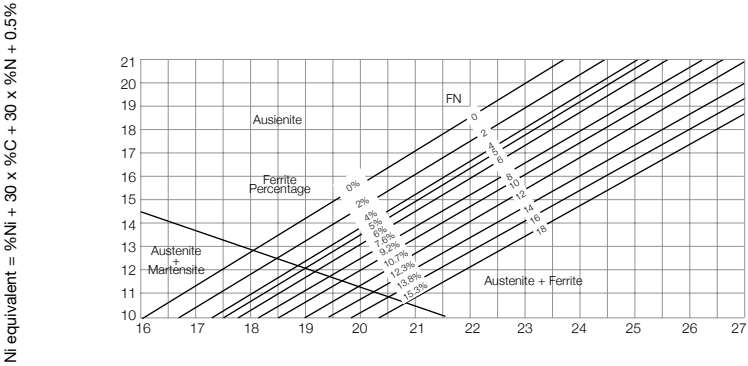
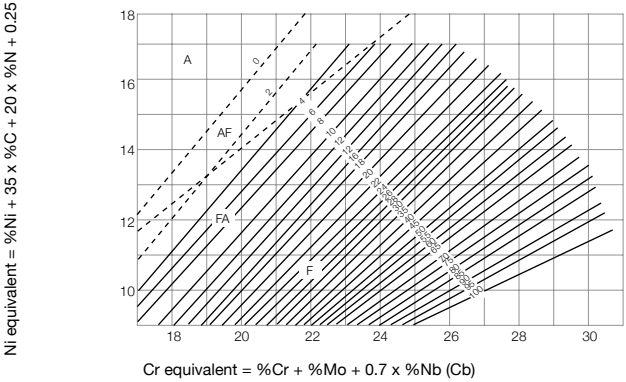


Fig. 4 WRC Diagram



A,AF,FA,F stand for soliditification modes
A : Austenitic single phase (r)
AF : Primary phase (r) + Elutectic Ferrite ( )
FA : primary phase ( ) + peritectic / Elutectic phase (r)
F : Single phase solodification
WRC : Welding Research Council
FN : Ferrite Number

JIS Z3321 Y308
AWS A5.9 ER308
DIN 8556-SG 1.4302

MS M-308 Solid Wires for Stainless Steel

Applications

Suitable for 18%Cr-8%Ni,19%Cr-9%N and 20%Cr10%N stainless steel.
Used to weld base metals of similar composition inparticalar type 304

Brand Name	MS M-308								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	9.0-11.0	19.5-22.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196° C 49 J								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y308L
AWS A5.9 ER308L
DIN 8556-SG 1.4316

MS M-308L Solid Wires for Stainless Steel

Applications

Suitable for low carbon18%Cr-8%Ni stainless steel. This filler metal reduces the possibility of intergranular carbide precipitation.

Brand Name	MS M-308L								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	9.0 - 11.0	19.5 - 22.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196° C 59 J								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y308LSi
AWS A5.9 ER308LSi
DIN 8556-SG 1.4316

MS M-308LSi Solid Wires for Stainless Steel

Applications

Suitable for low carbon18%Cr-8%Ni stainless steel
The arc stability, bead width and blow hole resistibility is good because of high silicon. It can be applied to multi-layer welding.

Brand Name	MS M-308LSi								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65 -1.00	1.0- 2.5	≤ 0.03	≤ 0.03	9.0 - 11.0	19.5 - 22.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm²								
0.2% Offset strength	≥ 205 N/mm²								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196° C 59 J								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

Gas Metal Arc Welding

MS M-308N2 Solid Wires for Stainless Steel

Applications Suitable for welding of 304N2 stainless steel

Brand Name	MS M-308N2								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	N
	≤ 0.10	≤ 0.90	1.0-4.0	≤ 0.03	≤ 0.03	7.0 - 11.0	20.0-25.0	-	0.12-0.30
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y309
AWS A5.9 ER309
DIN 8556-SG 1.4829

MS M-309 Solid Wires for Stainless Steel

Applications

Suitable for dissimilar-metal joint and underlaying on ferritic steels for overlaying stainless steel weld metals, such as joining type 304 to carbon steel.

Brand Name	MS M-309								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.12	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	12.0 - 14.0	23.0 - 25.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y309L
AWS A5.9 ER309L
DIN 8556-SG 1.4332

MS M-309L Solid Wires for Stainless Steel

Applications

Suitable for dissimilar-metal joint and underlaying on ferritic steels for overlaying stainless steel weld metals. Usage as MS M-309, but the 0.03% maximun carbon increases resistance to intergranular corrosion.

Brand Name	**MS M-309L**								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	12.0 - 14.0	23.0-25.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS -
AWS A5.9 ER309LSi
DIN 8556-SG 1.4332

MS M-309LSi Solid Wires for Stainless Steel

Applications

Suitable for dissimilar-metal joint and underlaying on ferritic steels for overlaying stainless steel weld metals. Usage as MS M-309L, but the 0.65-1.0% silicon content improves wetting behavior in the gas shielded welding process.

Brand Name	MS M-309LSi								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65 1.00	1.0-2.5	≤ 0.03	≤ 0.03	12.0-14.0	23.0-25.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm²								
0.2% Offset strength	≥ 205 N/mm²								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196° C 49 J								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y309Mo
AWS A5.9 ER309Mo
DIN 8556-SG 1.4459

MS M-309Mo Solid Wires for Stainless Steel

Applications

Suitable for welding of stainless steel to carbon steel and root runs in cladding.Addition 2.03.0%Mo to increase its pitting corrosion resistance in halide-containing environments.

Brand Name	MS M-309Mo								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.12	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	12.0 - 14.0	23.0-25.0	2.0-3.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y310
AWS A5.9 ER310
DIN 8556-SG 1.4842

MS M-310 Solid Wires for Stainless Steel

Applications

Suitable for welding of similar composition (26.5%Cr21%Ni) or clad part of 18%Cr-8%Ni stainless steel.Owing to the high contents of alloying elements,ductility maintained in welding of carbon steel where deposited metal is diluted by base metal steel.

Brand Name	MS M-310								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.15	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	20.0-22.5	25.0-28.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250A	170-300A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

MS M-310S **Solid Wires for Stainless Steel**

Applications Suitable for welding of 310S stainless steel

Brand Name	**MS M-310S**								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	20.0 - 22.5	25.0-28.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250A	170-300A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y312
AWS A5.9 ER312
DIN 8556-SG 1.4337

MS M-312 Solid Wires for Stainless Steel

Applications

Suitable for welding of dissimilar metals such as stainless steel, carbon steel and low alloy steel. MS M-312 has excellent usability and weldability.
Owing to the austenite structure containing large cotents of ferrite,MS M-312 has good crack resistibility steel.

Brand Name	MS M-312								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.15	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	8.0-10.5	28.0 - 32.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250A	170-300A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y316
AWS A5.9 ER316
DIN 8556-SG 1.4403

MS M-316 Solid Wires for Stainless Steel

Applications

Suitable for welding of 18%Cr-12%Ni-2%Mo stainless steel, 13%Cr steel,17%Cr steel and high toughness steel when postheating is not recommended. Use for welding between dissimilar metal like carbon steeland stainless steel.

Brand Name	**MS M-316**								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.08	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	11.0-14.0	18.0-20.0	2.0-3.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 30 %								
Impact test	2mm Vnotch Impact value at -196° C 39 J								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6mm
	80-180A	120-200A	140-250A	170-300A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y316L
AWS A5.9 ER316L
DIN 8556-SG 1.4430

MS M-316L Solid Wires for Stainless Steel

Applications

Suitable for welding of extra-low carbon 18%Cr-12% Ni 2%Mo stainless steel.
In this filler metal reduces the possibility of intergranular choromium carbide precipitation.

Brand Name	MS M-316L								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	11.0-14.0	18.0-20.0	2.0-3.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196° C 49 J								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250A	170-300A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y316LSi
AWS A5.9 ER316LSi
DIN 8556-SG 1.4430

MS M-316LSi Solid Wires for Stainless Steel

Applications

Suitable for welding of extra-low carbon 18%Cr-12%Ni-2%Mo stainless steel. Usage as MS M-316L, but the 0.65-1.0% silicon content improves wetting behavior in the gas shielded welding process.

Brand Name	MS M-316LSi								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	0.65-1.00	1.0-2.5	≤ 0.03	≤ 0.03	11.0-14.0	18.0-20.0	2.0-3.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196° C 49 J								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250A	170-300A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y16-8-2
AWS A5.9 ER16-8-2
DIN -

MS M-16-8-2 Solid Wires for Stainless Steel

Applications

Suitable for type 16-8-2,316 and 347 for high-pressure high-temperature piping systems.The deposit also has good hot-ductility properties.

Brand Name	MS M-16-8-2								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.10	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	7.5-9.5	14.5 - 16.5	1.0 - 2.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250A	170-300A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

MS M-316J1L Solid Wires for Stainless Steel

Applications Suitable for welding of 316J1L stainless steel.

Brand Name	MS M-316J1L								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Cu
	0.030	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	11.0 - 14.0	18.0 - 20.0	2.0 - 3.0	1.0- 2.5
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y317
AWS A5.9 ER317
DIN 8556-SG 1.4440

MS M-317 Solid Wires for Stainless Steel

Applications

Suitable for welding of 317 stainless steel is utilized in severely corrosive environments where crevie and pitting corrosion are of concern

Brand Name	MS M-317								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	13.0-15.0	18.5 20.5	3.0 4.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y317L
AWS A5.9 ER317L
DIN 8556-SG 1.4440

MS M-317L Solid Wires for Stainless Steel

Applications

Suitable for welding of 317L stainless steel. Usde same as MS M-317 and reduces the possibility of intergranular carbide precipitation

Brand Name	MS M-317L								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	13.0 - 15.0	18.5-20.5	3.0-4.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

MS M-321 Solid Wires for Stainless Steel

Applications

Suitable for welding of 321 stainless steel. With Titanium added.
The Titanium acts in the same way Nb(Cb) in type 347 and thus increasing resistance to intergranular corrosion

Brand Name	MS M-321								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Ti
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	9.0-10.5	18.5-20.5	-	9xC-1.0
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y347
AWS A5.9 ER347
DIN 8556-SG 1.4551

MS M-347 Solid Wires for Stainless Steel

Applications

Suitable for welding of 316,316L and 318 stainless steel. With Nb(Cb) added as a stabilizer and reduces the possibility of intergraular chromium carbide precipitation

Brand Name	MS M-347								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Nb
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	9.0-11.0	19.0-21.5	-	10xC -1.0
Mechanical property of deposited metal									
Tensile strength	≥ 550 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

MS M-347L Solid Wires for Stainless Steel

Applications

Suitable for welding of 316,316L and 318 stainless steel. Low carbon content than MS M-347,with Nb(Cb) added as a stabilizer and reduces the possibility of intergranular chromium carbide precipitation

Brand Name	MS M-347L								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Nb
	≤ 0.030	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	9.0-11.0	19.0-21.5	-	10xc -1.0
Mechanical property of deposited metal									
Tensile strength	≥ 510 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y410
AWS A5.9 ER410
DIN 8556-SG 1.4009

MS M-410 Solid Wires for Stainless Steel

Applications

Suitable for welding of 405,410,410S stainless steel is an air-hardening steel. Preheat and posheat trealments are required to achieve welds of adequate ductility for many engineering purposes.

Brand Name	MS M-410								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.12	≤ 0.50	≤ 0.6	≤ 0.03	≤ 0.03	≤ 0.6	11.5-13.5	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 450 N/mm^2								
0.2% Offset strength	-								
Elongation	≥ 20 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

JIS Z3321 Y430
AWS A5.9 ER430
DIN 8556-SG 1.4015

MS M-430 Solid Wires for Stainless Steel

Applications

Suitable for welding 430,405 stainless steel. The MS M-430 classification usually requires preheating and postweld heat treatment

Brand Name	MS M-430								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.10	≤ 0.50	≤ 0.6	≤ 0.03	≤ 0.03	≤ 0.6	15.5-17.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 450 N/mm²								
0.2% Offset strength	-								
Elongation	≥ 20 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

MS M-430MR Solid Wires for Stainless Steel

Applications: Suitable for 13-17%Cr type stainless steel for thin plate in muffler welding

Brand Name	MS M-430MR								
Representative of diameter (mm)	0.8	0.9	1.0	1.2	1.6	-	-	-	-
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Nb
	≤ 0.030	≤ 0.50	≤ 0.6	≤ 0.03	≤ 0.03	≤ 0.6	15.5-18.0	-	0.4-0.8
Mechanical property of deposited metal									
Tensile strength	≥ 450 N/mm^2								
0.2% Offset strength	-								
Elongation	≥ 20 %								
Impact test	NA								

Welding position	Horizontal/Flat position				
Welding polarity	DC-EP				
Shielding gas	98%Ar - 2%O_2				
Welding current	Dia.0.8 mm	Dia.0.9 mm	Dia.1.0 mm	Dia.1.2 mm	Dia.1.6 mm
	80-180A	120-200A	140-250 A	170-300 A	200-350A
Packing	12.50 kgs standard other packing weight can be provided upon request.				

Gas Tungsten Arc Welding

MS T-308 Filler Rod for Stainless Steel

Applications: Suitable for 18%Cr-8%Ni stainless steel. Used to weld base metals of similar composition inparticalar type 304

Brand Name	MS T-308								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Chemical composition of lenght	1000 mm Standard or 950 mm Upon requested.								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	9.0-11.0	19.5 22.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196 °C 39J								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS Z3321 Y308L
AWS A5.9 ER308L
DIN 8556-SG 1.4316

MS T-308L Filler Rod for Stainless Steel

Applications

Suitable for low carbon18%Cr-8%Ni stainless steel. This filler metal reduces the possibility of intergranular carbide precipitation.

Brand Name	MS T-308L								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Chemical composition of lenght	1000 mm Standard or 950 mm Upon requested.								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	9.0-11.0	19.5-22.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 500 N/mm²								
0.2% Offset strength	≥ 205 N/mm²								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196 °C 39J								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS -
AWS A5.9 ER308LSi
DIN 8556-SG 1.4316

MS T-308LSi Filler Rod for Stainless Steel

Applications

Suitable for low carbon18%Cr-8%Ni stainless steel. The arc stability,bead width and blow hole resistibility is good because of high silicon. It can be applied to multi-layer welding.

Brand Name	MS T-308LSi								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Chemical composition of lenght	1000 mm Standard or 950 mm Upon requested.								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	0.65-1.00	1.0-2.5	≤ 0.03	≤ 0.03	9.0-11.0	19.5 22.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 500 N/mm²								
0.2% Offset strength	≥ 205 N/mm²								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-308N2 **Filler Rod for Stainless Steel**

Applications Suitable for welding of 304N2 stainless steel

Brand Name	**MS T-308N2**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Chemical composition of lenght	1000 mm Standard or 950 mm Upon requested.								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	N
	≤ 0.10	≤ 0.90	1.0-4.0	≤ 0.03	≤ 0.03	7.0-11.0	20.0 25.0	-	0.12-0.30
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-309 Filler Rod for Stainless Steel

Applications

Suitable for dissimilar-metal joint and underlaying on ferritic steels for overlaying stainless steel weld metals, such as joining type 304 to carbon steel.

Brand Name	MS T-309								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Chemical composition of lenght	1000 mm Standard or 950 mm Upon requested.								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.12	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	12.0-14.0	23.0 25.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-309L Filler Rod for Stainless Steel

Applications

Suitable for dissimilar-metal joint and underlaying on ferritic steels for overlaying stainless steel weld metals. Usage as MS M-309, but the 0.03% maximum carbon increases to intergranular corrosion.

Brand Name	MS T-309L								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Chemical composition of lenght	1000 mm Standard or 950 mm Upon requested.								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65	1.0-2.50	≤ 0.03	≤ 0.03	12.0-14.0	23.0 25.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 500 N/mm²								
0.2% Offset strength	≥ 205 N/mm²								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -0° C 88J								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm.v
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS -
AWS A5.9 ER309LSi
DIN 8556-SG 1.4332

MS T-309LSi Filler Rod for Stainless Steel

Applications

Suitable for dissimilar-metal joint and underlaying on ferritic steels for overlaying stainless steel weld metals. Usage as MS M-309L, but the 0.65-1.0% silicon content improves wetting behavior in the gas shielded welding process.

Brand Name	MS T-309LSi								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Chemical composition of lenght	1000 mm Standard or 950 mm Upon requested.								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	0.65-1.00	1.0-2.5	≤ 0.03	≤ 0.03	12.0-14.0	23.0-25.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -0 °C 80J								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS Z3321 Y309Mo
AWS A5.9 ER309Mo
DIN 8556-SG 1.4459

MS T-309Mo Filler Rod for Stainless Steel

Applications

Suitable for welding of stainless steel to carbon steel and root runs in cladding. Addition 2.0-3.0%Mo to increase its pitting corrosion resistance in halide-containing environments.

Brand Name	MS T-309Mo								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Chemical composition of lenght	1000 mm Standard or 950 mm Upon requested.								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.12	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	12.0-14.0	23.0 25.0	2.0-3.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-310 **Filler Rod for Stainless Steel**

Applications

Suitable for welding of similar composition (26.5%Cr-21%Ni) or clad part of a18%Cr-8%Ni stainless steel. Owing to the high contents of alloying elements, ductility maintained in welding of carbon steel where deposited metal is diluted by base metal steel.

Brand Name	**MS T-310**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.15	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	20.0-22.5	25.0-28.0	-	-
Mechanical property of deposited metal									
Tensile strength	> 540 N/mm²								
0.2% Offset strength	> 225 N/mm²								
Elongation	> 35 %								
Impact test	NA								

Welding position	All position		Welding polarity
DC-EN		Shielding gas	Ar
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
		Packing	
Inner case weight (kg)		5.00	

JIS Z3321 Y310S
AWS A5.9 ER310S
DIN 8556-SG 1.4842

MS T-310S **Filler Rod for Stainless Steel**

Applications Suitable for welding of 310S stainless steel.

Brand Name	**MS T-310S**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	20.0-22.5	25.0-28.0	-	-
Mechanical property of deposited metal									
Tensile strength	> 540 N/mm²								
0.2% Offset strength	> 225 N/mm²								
Elongation	> 35 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-312 **Filler Rod for Stainless Steel**

Applications

Suitable for welding of dissimilar metals such as stainless steel, carbon steel and low alloy steel. MS M-312 has excellent usability and weldability. Owing to the austenite structure containing large contents of ferrite, MS M-312 has good crack resistibility.

Brand Name	**MS T-312**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.15	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	8.0-10.5	28.0-32.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

JIS Z3321 Y316
AWS A5.9 ER316
DIN 8556-SG 1.4403

MS T-316 **Filler Rod for Stainless Steel**

Applications

Suitable for welding of 18%Cr-12%Ni-2%Mo stainless steel, 13%Cr steel, 17%Cr steel and high toughness steel when postheating is not recommended. Use for welding between dissimilar metal like carbon steel and stainless steel

Brand Name	**MS T-316**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	11.0-14.0	18.0-20.0	2.0-3.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 30 %								
Impact test	2mm Vnotch Impact value at -196° C 39 J								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-316L **Filler Rod for Stainless Steel**

Applications Suitable for welding of extra-low carbon 18%Cr-12%Ni-2%Mo stainless steel. In this filler metal reduces the possibility of intergranular choromium carbide precipitation

Brand Name	**MS T-316L**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	11.0-14.0	18.0-20.0	2.0-3.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 500 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 35 %								
Impact test	2mm Vnotch Impact value at -196° C 39 J								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS -
AWS A5.9 ER316LSi
DIN 8556-SG 1.4430

MS T-316LSi **Filler Rod for Stainless Steel**

Applications

Suitable for welding of extra-low carbon 18%Cr-12%Ni-2%Mo stainless steel. Usage as MS M-316L, but the 0.65-1.0% silicon content improves wetting behavior in the gas shielded welding process.

Brand Name	**MS T-316LSi**								
Representative of diameter (mm.)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	0.65-1.0	1.0-2.5	≤ 0.03	≤ 0.03	11.0-14.0	18.0-20.0	2.0-3.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 500 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-16-8-2 Filler Rod for Stainless Steel

Applications

Suitable for type 16-8-2,316 and 347 for high-pressure, high-temperature piping systems. The deposit also has good hot-ductility properties which offer greater freedom from weld or creter cracking even under restraint condition.

Brand Name	MS T-16-8-2								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.10	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	7.5-9.5	14.5-16.5	1.0-2.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-316J1L **Filler Rod for Stainless Steel**

Applications Suitable for welding of 316J1L stainless steel.

Brand Name	**MS T-316J1L**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Cu
	≤ 0.030	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	11.0-14.0	18.0-20.0	2.0-3.0	1.0-2.5
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 35 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS Z3321 Y317
AWS A5.9 ER317
DIN 8556-SG 1.4440

MS T-317 **Filler Rod for Stainless Steel**

Applications Suitable for welding of 317 stainless steel is utilized in severely corrosive environments where crevie and pitting corrosion are of concern

Brand Name	**MS T-317**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.08	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	13.0-15.0	18.5-20.5	3.0-4.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm²								
0.2% Offset strength	≥ 225 N/mm²								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS Z3321 Y317L
AWS A5.9 ER317L
DIN 8556-SG 1.4440

MS T-317L **Filler Rod for Stainless Steel**

Applications

Suitable for welding of 317L stainless steel. Used same as MS T-317 and reduces the possibility of intergranular carbide precipitation and increases the resistance to intergranular corrosion.

Brand Name	**MS T-317L**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.030	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	13.0-15.0	18.5-20.5	3.0-4.0	-
Mechanical property of deposited metal									
Tensile strength	≥ 500 N/mm^2								
0.2% Offset strength	≥ 205 N/mm^2								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-321 **Filler Rod for Stainless Steel**

Applications Suitable for welding of 321 stainless steel. With Titanium added. The Titanium acts in the same way Nb(Cb) in type 347 and thus increasing resistance to intergranular corrosion

Brand Name	**MS T-321**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Ti
	≤ 0.08	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	9.0-10.5	18.5-20.5	-	9xC -1.0
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

JIS Z3321 Y347
AWS A5.9 ER347
DIN 8556-SG 1.4551

MS T-347 **Filler Rod for Stainless Steel**

Applications Suitable for welding of 316,316L and 318 stainless steel. With Nb(Cb) added as a stabilizer and reduces the possibility of intergraular chromium carbide precipitation

Brand Name	**MS T-347**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Nb
	≤ 0.08	≤ 0.65	1.0-2.5	≤ 0.03	≤ 0.03	9.0-11.0	19.0-21.5	-	10xC -1.0
Mechanical property of deposited metal									
Tensile strength	≥ 540 N/mm^2								
0.2% Offset strength	≥ 225 N/mm^2								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS Z3321 Y347L
AWS A5.9 ER347L
DIN 8556-SG 1.4551

MS T-347L **Filler Rod for Stainless Steel**

Applications

Suitable for welding of 316,316L and 318 stainless steel. Low carbon content than MS T-347, with Nb(Cb) added as a stabilizer and reduces the possibility of intergranular chromium carbide precipitation

Brand Name	**MS T-347L**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Nb
	≤ 0.030	≤ 0.65	1.0 - 2.5	≤ 0.03	≤ 0.03	9.0-11.0	19.0-21.5	-	10xC -1.0
Mechanical property of deposited metal									
Tensile strength	≥ 500 N/mm²								
0.2% Offset strength	≥ 205 N/mm²								
Elongation	≥ 30 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-410 **Filler Rod for Stainless Steel**

Applications

Suitable for welding of 405,410,410S stainless steel is an air-hardening steel. Preheat and posheat treatments are required to achieve welds of adequate ductility for many engineering purposes.

Brand Name	**MS T-410**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.12	≤ 0.50	≤ 0.6	≤ 0.03	≤ 0.03	≤ 0.6	11.5-13.5	≤ 0.75	-
Mechanical property of deposited metal									
Tensile strength	≥ 450 N/mm^2								
0.2% Offset strength	-								
Elongation	≥ 20 %								
Impact test	2mm Vnotch Impact value at 20° C 210J								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

JIS Z3321 Y430
AWS A5.9 ER430
DIN 8556-SG 1.4015

MS T-430 **Filler Rod for Stainless Steel**

Applications Suitable for welding of 430,405 stainless steel. The MS T-430 classification usually requires preheating and postweld heat treatment

Brand Name	**MS T-430**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	-
	≤ 0.10	≤ 0.50	≤ 0.6	≤ 0.03	≤ 0.03	≤ 0.6	15.5-17.0	-	-
Mechanical property of deposited metal									
Tensile strength	≥ 450 N/mm^2								
0.2% Offset strength	-								
Elongation	≥ 20 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Gas Tungsten Arc Welding

MS T-430MR **Filler Rod for Stainless Steel**

Applications Suitable for 13-17 %Cr type stainless steel for thin plate in muffler welding

Brand Name	**MS T-430MR**								
Representative of diameter (mm)	1.0	1.2	1.6	2.0	2.4	2.6	3.2	4.0	5.0
Representative of length	1000 mm Standard or 950 mm Upon requested								
Chemical composition of wire (%)	C	Si	Mn	P	S	Ni	Cr	Mo	Nb
	≤ 0.030	≤ 0.50	≤ 0.6	≤ 0.03	≤ 0.03	≤ 0.6	15.5-18.0	-	0.4-0.8
Mechanical property of deposited metal									
Tensile strength	≥ 450 N/mm^2								
0.2% Offset strength	-								
Elongation	≥ 20 %								
Impact test	NA								

Welding position	All position		
Welding polarity	DC-EN		
Shielding gas	Ar		
Welding current	Dia. 1.2 mm	Dia. 1.6 mm	Dia. 2.4 mm
	30-80 A	40-120 A	50-150 A
Packing			
Inner case weight (kg)	5.00		

Hardness Conversation Table

Vickers Hardness (DPH)	Brinell hardness 10mm Ball 3,000kg load		Rockwell Hardness		Shore Hardness	Tensile Strength (kgf/mm2) (approx)
		Tungsten Carbide Ball	B scale	C scale		
940	-	-	-	68.0	97	-
920	-	-	-	67.5	96	-
900	-	767	-	67.0	95	-
880	-	757	-	66.4	93	-
860	-	757	-	65.9	92	-
840	-	745	-	65.3	91	-
820	-	733	-	64.7	90	-
800	-	722	-	64.0	88	-
780	-	710	-	63.5	87	-
760	-	698	-	62.6	86	-
740	-	684	-	61.8	84	-
720	-	670	-	61.0	83	-
700	-	656	-	60.1	81	-
690	-	647	-	59.7	-	-
680	-	638	-	59.2	80	-
670	-	630	-	58.8	-	227
660	-	620	-	58.3	79	224
650	-	611	-	57.8	-	220
640	-	601	-	57.3	77	217
630	-	591	-	56.8	-	213
620	-	582	-	56.3	75	210
610	-	573	-	55.7	-	206
600	-	564	-	55.2	74	203
590	-	554	-	54.7	-	199
580	-	545	-	54.1	72	196
570	-	535	-	53.6	-	192
560	-	525	-	53.0	71	189
550	505	517	-	52.3	-	185
540	496	507	-	51.7	69	182
530	488	497	-	51.1	-	178
520	480	488	-	50.5	67	175
510	473	479	-	49.8	-	171
500	465	471	-	49.0	66	168
490	456	460	-	48.4	-	164
480	448	452	-	47.7	64	161
470	441	442	-	46.9	-	157
460	433	433	-	46.1	62	154
450	425	425	-	45.3	-	150
440	415	415	-	44.5	59	147
430	405	405	-	43.6	-	143
420	397	397	-	42.7	57	140

Hardness Conversation Table

Vickers Hardness (DPH)	Brinell hardness 10mm Ball 3,000kg load	Tungsten Carbide Ball	Rockwell Hardness B scale	Rockwell Hardness C scale	Shore Hardness	Tensile Strength (kgf/mm2) (approx)
410	388	388	-	41.8	-	137
400	379	379	-	40.8	55	133
390	369	369	-	39.8	-	130
380	360	360	(110.0)	38.8	52	126
370	350	350	-	37.7	-	123
360	341	341	(109.0)	36.5	50	119
350	331	331	-	35.5	-	116
340	322	322	(108.0)	34.4	47	113
330	313	313	-	33.3	-	109
320	303	303	(107.0)	32.2	45	106
310	294	294	-	31.0	-	102
300	284	284	(105.5)	29.8	42	99
295	280	280	-	29.2	-	97.8
290	275	275	(104.5)	28.5	41	95.2
285	270	270	-	27.8	-	94.1
280	265	266	(103.5)	27.1	40	92.0
275	261	261	-	26.4	-	90.6
270	256	256	(102.0)	25.6	38	88.6
265	252	252	-	24.8	-	87.2
260	247	248	(101.2)	24.0	37	85.1
255	243	243	-	23.1	-	83.7
250	238	238	99.5	22.2	36	81.0
245	233	233	-	21.3	-	80.1
240	228	228	98.1	20.3	34	78.0
230	219	219	96.7	(18.0)	33	74.5
220	209	209	95.0	(15.7)	32	71.0
210	200	200	93.6	(13.4)	30	68.2
190	181	181	89.5	(8.5)	28	61.8
180	171	171	87.1	(6.0)	26	59.0
170	162	162	85.0	(0.3)	25	55.5
160	152	152	81.7	(0.0)	24	52.7
150	143	143	78.7	-	22	49.9
140	133	133	75.0	-	21	46.4
130	124	124	71.2	-	20	43.6
120	114	114	66.7	-	-	40.1
110	105	105	62.3	-	-	-
105	95	95	56.2	-	-	-
95	90	90	52.2	-	-	-
90	86	86	48.0	-	-	-
85	81	81	41.0	-	-	-

Stress Conversion Table (1)

lbs/in2	0,000	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000
Kgf/mm2	Kgf/mm2	Kgf/mm2	Kgf/mm2	Kgf/mm2	Kgf/mm2	Kgf/mm2	Kgf/mm2	Kgf/mm2	Kgf/mm2	Kgf/mm2
0.000	0.000	0.703	1.406	2.109	2.812	3.515	4.218	4.922	5.625	6.328
10,000	7.030	7.733	8.436	9.139	9.842	10.545	11.248	11.951	12.654	13.357
20,000	14.060	14.763	15.466	16.169	16.872	17.575	18.278	18.981	19.684	20.387
30,000	21.090	21.793	22.496	23.199	23.902	24.605	25.308	26.011	26.714	27.417
40,000	28.120	28.823	29.526	30.229	30.932	31.635	32.338	33.041	33.744	34.447
50,000	35.150	35.853	36.556	37.259	37.962	38.665	39.368	40.071	40.774	41.477
60,000	42.180	42.883	43.586	44.289	44.992	45.695	46.398	47.101	47.804	48.507
70,000	49.210	49.913	50.616	51.319	52.022	52.725	53.428	54.131	54.834	55.537
80,000	56.240	56.943	57.646	58.349	59.052	59.755	60.458	61.161	61.864	62.567
90,000	63.270	63.973	64.676	65.379	66.082	66.785	67.488	68.191	68.894	69.597
100,000	70.300	71.003	71.706	72.409	73.112	73.815	74.518	75.221	75.924	76.627
110,000	77.330	78.033	78.736	79.439	80.142	80.845	81.548	82.251	82.954	83.657
120,000	84.360	85.063	85.766	86.469	87.172	87.875	88.578	89.281	89.984	90.687
130,000	91.390	92.093	92.796	93.499	94.202	94.905	95.608	96.311	97.014	97.717
140,000	98.420	99.123	99.826	100.529	101.232	101.935	102.638	103.341	104.044	104.747
150,000	105.450	106.153	106.856	107.559	108.262	108.965	109.668	110.371	111.074	111.777
160,000	112.480	113.183	113.886	114.589	115.292	115.995	116.698	117.401	118.104	118.807
170,000	119.510	120.213	120.916	121.619	122.322	123.025	123.728	124.431	125.134	125.837
180,000	126.540	127.243	127.946	128.649	129.352	130.055	130.758	131.461	132.164	132.867
190,000	133.570	134.273	134.976	135.679	136.382	137.085	137.788	138.491	139.194	139.897
200,000	140.600	141.303	142.006	142.709	143.412	144.115	144.818	145.521	146.224	146.927
210,000	147.630	148.333	149.036	149.739	150.442	151.145	151.848	152.551	153.254	153.957
220,000	154.660	155.363	156.066	156.769	157.472	158.175	158.878	159.581	160.284	160.987
230,000	161.690	162.393	163.096	163.799	164.502	165.205	165.908	166.611	167.314	168.017
240,000	168.720	169.423	170.126	170.829	171.532	172.235	172.938	173.641	174.344	175.047
250,000	175.750	176.453	177.156	177.859	178.562	179.265	179.968	180.671	181.374	182.077

lbs/in2	100	200	300	400	500	600	700	800	900
Kgf/mm2	0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5624	0.6327

Stress Conversion Table (2)

(Kgf/mm^2 ⟶ N/mm^2 or Mpa)
Conversion version Factor: $1kgf/mm^2=9.80665N/mm^2$

IKgf/mm²	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Kgf/mm²
9.80665	N/mm²										
-		0.9807	1.9613	2.9420	3.9227	4.9033	5.8840	6.8647	7.8453	8.8260	-
1	9.8067	10.787	11.768	12.749	13.729	14.710	15.691	16.671	17.652	18.633	1
2	19.613	20.594	21.575	22.555	23.536	24.517	25.497	26.478	27.459	28.439	2
3	29.420	30.401	31.381	32.362	33.343	34.323	35.304	36.285	37.265	38.246	3
4	39.227	40.207	41.188	42.169	43.149	44.130	45.111	46.091	47.072	48.053	4
5	49.033	50.014	50.995	51.975	52.956	53.937	54.917	55.898	56.879	57.859	5
6	58.840	59.821	60.801	61.782	62.763	63.743	64.724	65.705	66.685	67.666	6
7	68.647	69.627	70.608	71.589	72.569	73.550	74.531	75.511	76.492	77.473	7
8	78.453	79.434	80.415	81.395	82.376	83.357	84.337	85.318	86.299	87.279	8
9	88.260	89.241	90.221	91.202	92.183	93.163	94.144	95.125	96.105	97.086	9
10	98.067	99.047	100.03	101.01	101.99	102.97	103.95	104.93	105.91	106.89	10
11	107.87	108.85	109.83	110.82	111.80	112.78	113.76	114.74	115.72	116.70	11
12	117.68	118.66	119.64	120.62	121.60	122.58	123.56	124.54	125.53	126.51	12
13	127.49	128.47	129.45	130.43	131.41	132.39	133.37	134.35	135.33	136.31	13
14	137.29	138.27	139.25	140.24	141.22	142.20	143.18	144.16	145.14	146.12	14
15	147.10	148.08	149.06	150.04	151.02	152.00	152.98	153.96	154.95	155.93	15
16	156.91	157.89	158.87	159.85	160.83	161.81	162.79	163.77	164.75	165.73	16
17	166.71	167.69	168.67	169.66	170.64	171.62	172.60	166.71	174.56	175.54	17
18	176.52	177.50	178.48	179.46	180.44	181.42	182.40	183.38	184.37	185.35	18
19	186.33	187.31	188.29	189.27	190.25	191.23	192.21	193.19	194.17	195.15	19
20	196.13	197.11	198.09	199.07	200.06	201.04	202.02	203.00	203.98	204.96	20
21	205.94	206.92	207.90	208.88	209.86	210.84	211.82	212.80	213.78	214.77	21
22	215.75	216.73	217.71	218.69	219.67	220.65	221.63	222.61	223.59	224.57	22
23	225.55	226.53	227.51	228.49	229.48	230.46	231.44	232.42	233.40	234.38	23
24	235.36	236.34	237.32	238.30	239.28	240.26	241.24	242.22	243.20	244.19	24

bs/in²	100	200	300	400	500	600	700	800	900
Kgf/mm²	0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5624	0.6327

Stress Conversion Table (3)

(Kgf/mm² ⟶ N/mm² or Mpa)
Conversion version Factor: 1kgf/mm²=9.80665N/mm²

IKgf/mm²	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Kgf/mm²
9.80665	N/mm²										
25	245.17	246.15	247.13	248.11	249.09	250.07	251.05	252.03	253.01	253.99	25
26	254.97	255.95	256.93	257.91	258.90	259.88	260.86	261.84	262.82	263.80	26
27	264.78	265.76	266.74	267.72	268.70	269.68	270.66	271.64	272.62	273.61	27
28	274.59	275.57	276.55	277.53	278.51	279.49	280.47	281.45	282.43	283.41	28
29	284.39	285.37	286.35	287.33	288.32	289.30	290.28	291.26	292.24	293.22	29
30	294.20	295.18	296.16	297.14	298.12	299.10	300.08	301.06	302.04	303.03	30
31	304.01	304.99	305.97	306.95	307.93	308.91	309.89	310.87	311.85	312.83	31
32	313.81	314.79	315.77	316.75	317.74	318.72	319.70	320.68	321.66	322.64	32
33	323.62	324.60	325.58	326.56	327.54	328.52	329.50	330.48	331.46	332.45	33
34	333.43	334.41	335.39	336.37	337.35	338.33	339.31	340.29	341.27	342.25	34
35	343.23	344.21	345.19	346.17	347.16	348.14	349.12	350.10	351.08	352.06	35
36	353.04	354.02	355.00	355.98	356.96	357.94	358.92	359.90	360.88	361.87	36
37	362.85	363.83	364.81	365.79	366.77	367.75	368.73	369.71	370.69	371.67	37
38	372.65	373.63	374.61	375.59	376.58	377.56	378.54	379.52	380.50	381.48	38
39	382.46	383.44	384.42	385.40	386.38	387.36	388.34	389.32	390.30	391.29	39
40	392.27	393.25	394.23	395.21	396.19	397.17	398.15	399.13	400.11	401.09	40
41	402.07	403.05	404.03	405.01	406.00	406.98	407.96	408.94	409.92	410.90	41
42	411.88	412.86	413.84	414.82	415.80	416.78	417.76	418.74	419.72	420.71	42
43	421.69	422.67	423.65	424.63	425.61	426.59	427.57	428.55	429.53	430.51	43
44	431.49	432.47	433.45	434.43	435.42	436.40	437.38	438.36	439.34	440.32	44
45	441.30	442.28	443.26	444.24	445.22	446.20	447.18	448.16	449.14	450.13	45
46	451.11	452.09	453.07	454.05	455.03	456.01	456.99	457.97	458.95	459.93	46
47	460.91	461.89	462.87	463.85	464.84	465.82	466.80	467.78	468.76	469.74	47
48	470.72	471.70	472.68	473.66	474.64	475.62	476.60	477.58	478.56	479.55	48
49	480.53	481.51	482.49	483.47	484.45	485.43	486.41	487.39	488.37	489.35	49

bs/in²	100	200	300	400	500	600	700	800	900
Kgf/mm²	0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5624	0.6327

Stress Conversion Table (4)

(Kgf/mm² ⟶ N/mm² or Mpa)
Conversion version Factor: 1kgf/mm²=9.80665N/mm²

IKgf/mm²	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Kgf/mm²
9.80665	N/mm²										
50	490.33	491.31	492.29	493.27	494.26	495.24	496.22	497.20	498.18	8.83	50
51	500.14	501.12	502.10	503.08	504.06	505.04	506.02	507.00	507.98	8.83	51
52	509.95	510.93	511.91	512.89	513.87	514.85	515.83	516.81	517.79	8.83	52
53	519.75	520.73	521.71	522.69	523.68	524.66	525.64	526.62	527.60	8.83	53
54	529.56	530.54	531.52	532.50	533.48	534.46	535.44	536.42	537.40	8.83	54
55	539.37	540.35	541.33	542.31	543.29	544.27	545.25	546.23	547.21	8.83	55
56	549.17	550.15	551.13	552.11	553.10	554.08	555.06	556.04	557.02	8.83	56
57	558.98	559.96	560.94	561.92	562.90	563.88	564.86	565.84	566.82	8.83	57
58	568.79	569.77	570.75	571.73	572.71	573.69	574.67	575.65	576.63	8.83	58
59	578.59	579.57	580.55	581.53	582.52	583.50	584.48	585.46	586.44	8.83	59
60	588.40	589.38	590.36	591.34	592.32	593.30	594.28	595.26	596.24	8.83	60
61	598.21	599.19	600.17	601.15	602.13	603.11	604.09	605.07	606.05	8.83	61
62	608.01	608.99	609.97	610.95	611.93	612.92	613.90	614.88	615.86	8.83	62
63	617.82	618.80	619.78	620.76	621.74	622.72	623.70	624.68	625.66	8.83	63
64	627.63	628.61	629.59	630.57	631.55	632.53	633.51	634.49	635.47	8.83	64
65	637.43	638.41	639.39	640.37	641.35	642.34	643.32	644.30	645.28	8.83	65
66	647.24	648.22	649.20	650.18	651.16	652.14	653.12	654.10	655.08	8.83	66
67	657.05	658.03	659.01	659.99	660.97	661.95	662.93	663.91	664.89	8.83	67
68	666.85	667.83	668.81	669.79	670.77	671.76	672.74	673.72	674.70	8.83	68
69	676.66	677.64	678.62	679.60	680.58	681.56	682.54	683.52	684.50	8.83	69
70	686.47	687.45	688.43	689.41	690.39	691.37	692.35	693.33	694.31	8.83	70
71	696.27	697.25	698.23	699.21	700.19	701.18	702.16	703.14	704.12	8.83	71
72	706.08	707.06	708.04	709.02	710.00	710.98	711.96	712.94	713.92	8.83	72
73	715.89	716.87	717.85	718.83	719.81	720.79	721.77	722.75	723.73	8.83	73
74	725.69	726.67	727.65	728.63	729.61	730.60	731.58	732.56	733.54	8.83	74

bs/in²	100	200	300	400	500	600	700	800	900
Kgf/mm²	0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5624	0.6327

Stress Conversion Table (5)

(Kgf/mm² ⟶ N/mm² or Mpa)
Conversion version Factor: 1kgf/mm²=9.80665N/mm²

IKgf/mm²	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Kgf/mm²
9.80665	N/mm²										
75	735.50	736.48	737.46	738.44	739.42	740.40	741.38	742.36	743.34	8.83	75
76	745.31	746.29	747.27	748.25	749.23	750.21	751.19	752.17	753.15	8.83	76
77	755.11	756.09	757.07	758.05	759.03	760.02	761.00	761.98	762.96	8.83	77
78	764.92	765.90	766.88	767.86	768.84	769.82	770.80	771.78	772.76	8.83	78
79	774.73	775.71	776.69	777.67	778.65	779.63	780.61	781.59	782.57	8.83	79
80	784.53	785.51	786.49	787.47	788.45	789.44	790.42	791.40	792.38	8.83	80
81	794.34	795.32	796.30	797.28	798.26	799.24	800.22	801.20	802.18	8.83	81
82	804.15	805.13	806.11	807.09	808.07	809.05	810.03	811.01	811.99	8.83	82
83	813.95	814.93	815.91	816.89	817.87	818.86	819.84	820.82	821.80	8.83	83
84	823.76	824.74	825.72	826.70	827.68	828.66	829.64	830.62	831.60	8.83	84
85	833.57	834.55	835.53	836.51	837.49	838.47	839.45	840.43	841.41	8.83	85
86	843.37	844.35	845.33	846.31	847.29	848.28	849.26	850.24	851.22	8.83	86
87	853.18	854.16	855.14	856.12	857.10	858.08	859.06	860.04	861.02	8.83	87
88	862.99	863.97	864.95	865.93	866.91	867.89	868.87	869.85	870.83	8.83	88
89	872.79	873.77	874.75	875.73	876.71	877.70	878.68	879.66	880.64	8.83	89
90	882.60	883.58	884.56	885.54	886.52	887.50	888.48	889.46	890.44	8.83	90
91	892.41	893.39	894.37	895.35	896.33	897.31	898.29	899.27	900.25	8.83	91
92	902.21	903.19	904.17	905.15	906.13	907.12	908.10	909.08	910.06	8.83	92
93	912.02	913.00	913.98	914.96	915.94	916.92	917.90	918.88	919.86	8.83	93
94	921.83	922.81	923.79	924.77	925.75	926.73	927.71	928.69	929.67	8.83	94
95	931.63	932.61	933.59	934.57	935.55	936.54	937.52	938.50	939.48	8.83	95
96	941.44	942.42	943.40	944.38	945.36	946.34	947.32	948.30	949.28	8.83	96
97	951.25	952.23	953.21	954.19	955.17	956.15	957.13	958.11	959.09	8.83	97
98	961.05	962.03	963.01	963.99	964.97	965.96	966.94	967.92	968.90	8.83	98
99	970.86	971.84	972.82	973.80	974.78	975.76	976.74	977.72	978.70	8.83	99

bs/in²	100	200	300	400	500	600	700	800	900
Kgf/mm²	0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5624	0.6327

Temperature Conversion Table

	0~45			46~91			92~450			460~910	
°C		°F	°C		°F	°C		°F	°C		°F
-17.8	0	32	7.7	46	114.8	33.3	92	197.6	238	460	860
-17.2	1	33.8	8.2	47	116.6	33.8	93	199.4	243	470	878
-16.7	2	35.6	8.8	48	118.8	34.4	94	201.2	249	480	896
-16.1	3	37.4	9.3	49	120.2	34.8	95	203.0	254	490	914
-15.6	4	39.2	9.9	50	122.0	35.5	96	204.8	260	500	932
-15.0	5	41.0	10.4	51	123.8	36.1	97	206.6	265	510	950
-14.4	6	42.8	11.1	52	125.6	36.6	98	208.4	265	510	950
-13.9	7	44.6	11.5	53	127.4	37.1	99	210.2	276	530	986
-13.3	8	46.4	121	54	129.2	37.7	100	210.0	282	540	1004
-12.8	9	48.2	12.6	55	131.0	38	100	212	288	550	1022
-12.2	10	50.0	13.2	56	132.8	43	110	230	293	560	1040
-11.7	11	51.8	13.7	57	134.6	49	120	248	299	570	1058
-11.1	12	53.6	14.3	58	136.4	54	130	266	304	580	1076
-10.6	13	55.4	14.8	59	138.4	60	140	284	310	590	1094
-10.0	14	57.2	15.6	60	140.0	65	150	302	315	600	1112
-9.4	15	59.0	16.0	61	141.8	71	160	320	321	610	1130
-8.9	16	60.8	16.6	62	143.6	76	170	338	326	620	1148
-8.3	17	62.6	17.1	63	145.4	83	180	356	332	630	1166
-7.7	18	64.4	17.7	64	147.2	88	190	374	338	640	1184
-7.2	19	66.2	18.2	65	149.0	93	200	392	343	650	1202
-6.7	20	68	18.8	66	150.8	99	210	410	349	660	1220
-6.1	21	69.8	19.3	67	152.6	100	212	413	354	670	1238
-5.6	22	71.6	19.9	68	154.4	104	220	428	360	680	1256
-5.0	23	73.4	20.4	69	156.2	110	230	446	365	690	1274
-4.4	24	75.2	21.0	70	158.0	115	240	464	371	700	1292
-3.9	25	77.0	21.5	71	159.8	121	250	482	376	710	1310
-3.3	26	78.8	22.2	72	161.6	127	260	500	382	720	1328
-2.8	27	80.6	22.7	73	163.4	132	270	518	387	730	1346
-2.2	28	82.4	23.3	74	165.2	138	280	536	393	750	1382
-1.7	29	84.2	23.8	75	167.0	143	290	54	399	750	1382
-1.1	30	86.0	24.4	76	168.8	149	300	572	404	760	1400
-0.6	31	87.08	25.0	77	170.6	154	310	590	410	770	1418
0	32	89.6	25.5	78	172.4	160	320	608	415	780	1436
0.6	33	91.4	26.2	79	174.2	165	330	526	421	790	1454
1.1	34	93.2	26.8	80	176.0	171	340	644	426	800	1472
1.7	35	95.0	27.3	81	177.8	177	350	662	432	810	1490
2.2	36	96.8	27.7	82	179.6	182	360	680	438	820	1508
3.3	38	100.4	28.8	84	183.2	193	380	716	449	840	1544
3.9	39	102.2	29.3	85	185.0	199	390	734	454	850	1562
4.4	40	104.0	29.9	86	186.8	204	400	752	460	860	1580
5	41	105.8	30.4	87	188.6	210	410	770	465	870	1598
5.6	42	107.6	31.0	88	190.4	215	420	788	471	880	1616
6.1	43	109.4	31.5	89	192.2	221	430	806	476	890	1634
6.7	44	111.2	32.1	90	194.0	226	440	824	482	900	1652
7.2	45	113.0	32.6	91	195.8	232	450	842	487	910	1670

	0~45			46~91			92~450			460~910	
°C		°F	°C		°F	°C		°F	°C		°F
493	920	1688	748	1380	2516	1003	1840	3344	1260	2300	4172
498	930	1706	752	1390	2534	1008	1850	3326	1266	2310	4190
504	940	1724	760	1400	2552	1014	1860	3380	1271	2320	4208
510	950	1742	765	1410	2570	1019	1870	3398	1277	2330	4244
520	970	1778	776	1430	2606	1030	1890	3434	1288	2350	4262
526	980	1796	782	1440	2624	1036	1900	3452	1293	2360	4280
532	990	1714	787	1450	2642	1041	1910	3470	1299	2370	4298
538	1000	1832	793	1460	2660	1047	1920	3448	1304	2380	4316
543	1010	1850	798	1470	2678	1052	1930	3506	1310	2390	4334
549	1020	1868	804	1480	2696	1058	1940	3524	1316	2400	4552
555	1030	1886	809	1490	2714	1063	1950	3542	1321	2410	4370
560	1040	1904	815	1500	2732	1069	1960	3560	1327	2420	4388
565	1050	1922	820	1510	2750	1074	1970	3578	1332	2430	4406
571	1060	1940	827	1520	2768	1080	1980	3596	1338	2440	4424
576	1070	1958	831	1530	2786	1085	1990	3614	1343	2450	4442
582	1080	1976	838	1540	2804	1093	2000	3632	1349	2460	4460
587	1090	1994	842	1550	2822	1099	2010	3650	1354	2470	4478
593	1100	2012	849	1560	2840	1104	2020	3668	1360	2480	4496
604	1120	2048	860	1580	2876	1116	2040	3704	1371	2500	4532
609	1130	2066	864	1590	2894	1124	2050	3722	1377	2510	4550
616	1140	2084	871	1600	2912	1127	2060	3740	1382	2520	4568
620	1150	2102	876	1610	2300	1132	2070	3758	1388	2530	4586
626	1160	2120	882	1620	2948	1138	2080	3776	1393	2540	4604
631	1170	2138	887	1630	2966	1143	2090	3794	1399	2550	4622
637	1180	2156	893	1640	2984	1149	2100	3812	1404	2560	4640
642	1190	2174	898	1650	3002	1154	2110	3830	1410	2570	4658
648	1200	2192	904	1660	3020	1160	2120	3848	1416	2580	4676
653	1210	2210	909	1670	3038	1166	2130	3866	1421	2590	4694
695	1220	2228	915	1680	3056	1171	2140	3884	1427	2600	4712
664	1230	2246	920	1690	3074	1177	2150	3902	1432	2610	4730
670	1240	2264	926	1700	3092	1182	2160	3920	1438	2620	4748
675	1250	2282	934	1710	3110	1188	2170	3938	1443	2630	4766
682	1260	2300	937	1720	3128	1193	2180	3956	1449	2640	4784
686	1270	2318	942	1730	3146	1199	2190	3974	1454	2650	4802
692	1280	2336	948	1740	3164	1204	2200	3992	1460	2660	4820
697	1290	2354	953	1750	3182	1210	2210	4010	1466	2670	4838
704	1300	2372	959	1760	3200	1216	2220	4028	1471	2680	4856
708	1310	2390	964	1770	3218	1221	2230	4046	1477	2690	4874
715	1320	2408	970	1780	3236	1227	2240	4064	1482	2700	4892
719	1330	2426	975	1790	3255	1232	2250	4082	1488	2710	4810
726	1340	2444	981	1800	3272	1238	2260	4100	1493	2720	4928
734	1350	2462	986	1810	3290	1243	2270	4118	1499	2730	4946
737	1360	2480	992	1820	3308	1249	2280	4136	1504	2740	4964
741	1370	2498	997	1830	3326	1254	2290	4154	1510	2750	4982

Welding of Stainless Steel

Introduction.

This section is designed to provide the reader with a technical overview for welding the major types of stainless steel available today.

Types of Stainless Steels:

Stainless steels are an important grade of structural material used worldwide for a multitude of application based on their corrosion resistance, aesthetic appeal, low temperature properties, high strength and/or ease of cleaning and sterilising.

The main type of weldable stainless steels available include:

Austenitic stainless steels (AISI 200 and 300 series/ UNS S20000 and S30000 series) which are easy to weld and by far the most popular type-accounting for over 70% of the stainless steel sold around the world.

Ferritic stainless steels (AISI 400 series/ UNS S40000 series) which are weldable particularly in the sections and commonly used for elevated temperature applications.

Martensitic stainless steels (AISI 400 series/ UNS S40000 series) which are difficult to weld and commonly used for wear resistant applications.

Duplex stainless steels (UNS S30000 series) which are weldable with precautions and used for corrosion resistant applications as an alternative to 300 series austenitic stainless steels.

Welding of Stainless Steel

WELDING TECHNIQUE

The technique of welding stainless steels does not differ greatly from that of the welding of mild steel, but as the material being handled is very expensive, and exacting conditions of service are usually involved, extra precaution and attention to detail at all stages of fablication is desirable. In principle, all stainless steel for high-class work should be welded with a short arc.

Any techniques which aim at increasing the penetration, speed of travel or the use of wide weaving techniques are to be discouraged. Usually the lowest convenient current should be used. Weaving should be not wider than twice the diameter of the electrode for base material and electrodes of like composition, and even less for plate of dissimilar composition.

The edges of the preparation should be free from scale. Clamps and jigs are advisable when welding sheets thinner than 3mm. (1/8 in) while cooling blocks are helpful with sheets 1.6mm to 2.5mm (1/16 in to 3/32 in) thick. Thick welds, particularly on thin sheets, should be placed much closer together than is the usual practice for mild steel. This procedure is necessary as the thermal conductivity of these alloy steels is less and the coefficient of expansion is considerably greater than that of mild steel.

NOTE ON TECHNIQUE:

1 Ensure that the surface of the material in the weld area is clean and free from foreign matter.
2 Use the edge preparation shown in table 1 over the page.
3 Tack at the regular intervals, at about half the pitch used for mild steel.
4 Maintain a short arc during welding, to avoid loss of alloying material during transfer across the arc.

Welding of Stainless Steel

NOTE ON TECHNIQUE:

5 Use stringer passes rather than wide weaves
6 To minimise distortion, employ back step or block sequenceswhen welding.
7 Throughly remove slag from welds between passes.
8 When welding double V or U joints, balance the welding on each side, to minimise distortion.
9 Never use emery wheels or buffs for grinding or polishing stainless if they have previously been used for mild steel.
10 Do not use excessive welding current. Because of the high electrical resistance and low thermal conductivity the currents used with stainless steel electrodes are somewhat lower than those used for mild steel.

TABLE 1. EDGE PREPARATION FOR MANUAL METAL ARC WELDING:

Thickness (mm)	Edge preparation	Notes
Up to 1.5 (1/16”)		Square butt joint- not gap.
1.5 - 5.0 (1/16” - 3/16”)		Square butt joint- gap equal to half thickness.
5.0 - 13.0 (3/16” - 1/2”)		Single V preparation- 1.5mm (1/16”) landing, 1.5mm (1/16”) gap.

TABLE 1. EDGE PREPARATION FOR MANUAL METAL ARC WELDING:

Thickness (mm)	Edge preparation	Notes
13.0 - 20.0 (1/2" - 3/4")		Single V preparation- 3mm (1/8") landing, 3mm (1/8") gap.
Over 20 (3/4")		Double V preparation- 1.5mm (1/16") max. Landing,1.5mm (1/16") gap.
		Double U preparation- 3mm (1/8") landing, 1.5mm (1/16") to 3mm (1/8") gap.

Austenitic Stainless Steels

Austenitic stainless steels are easilywelded with all standard arc welding process, without preheat and using matching or near matching welding consumables. Because of their high thermal expansion and low thermal conductivity compared to carbon steel they will distort more during and after welding. This can be minimised by more frequent tacking prior to welding, balance and back step welding methods and the use of lower welding current and heat input parameters. Low carbon austenitic stainless steels are commonly used because they are less susceptible to sensitisation (or carbide precipitation) during welding or high temperature service which can result in intergranular corrosion in a caustic environment. Matching low carbon welding consumables (designated with an "L") are also commonly used to desensitise the weld deposit, in the same way as the parent metal, and eliminate the risk of intergranular corrosion of the welded joint.

The common welding consumable types used for welding the many austenitic stainless steel grades are shown in the following table.

Welding of Stainless Steel

Austenitic Stainless Steel Grades - Welding Consumable Selection Guide.

Stainless Steel Grade			Welding Consumable Type		
AISI No:	UNS No:	Werkstoffe No:	1st Choice	2nd Choice	3rd Choice
201	S20100	--	308 / 308L	316L	347
202	S20200	1.4371	308 / 308L	316L	347
205	S20500	--	308 / 308L	316L	347
209	S20910	1.4565	308 / 308L	316L	347
301	S30100	1.431	308 / 308L	316L	347
302	S30200	--	308 / 308L	316L	347
303	S30300	1.4305	312 (Weldall)	309L / 309Mo	308 / 308L
303Se	S30323		312 (Weldall)	309L / 309Mo	308 / 308L
304	S30400	1.4301	308 / 308L	316L	347
304L	S30403	1.4306	308 / 308L	316L	347
304H	S30409	1.4948	308H	308L	316L
304N	S30451	--	308L / 308	316L	347
304LN	S30453	1.4311	308L / 308	316L	347
305	S30500	1.4303	308 / 308L	316L	347
308	S30800	--	308 / 308L	316L	347
309	S30900	1.4828	309 / 309L / 309Mo	316L	--
309S	S30908	1.4833	309L / 309Mo	312 (Weldall)	--
310	S31000	1.4841	310	312 (Weldall)	--
310S	S31008	1.4845	310	312 (Weldall)	--
314	S31400	--	316 / 316L	312 (Weldall)	309L / 309Mo
316	S31600	1.4401	316 / 316L	318	309L / 309Mo
316L	S31603	1.4404	316L / 316	318	309L / 309Mo
316H	S31609	1.4919	316H	318L	309L / 309Mo
316N	S31651	--	316L / 316	316L / 318	309L / 309Mo
316LN	S31653	1.4406	316L / 316	318	309L / 309Mo
317	S31700	1.4429	317 / 317L	318	316L
317L	S31703	1.4438	317L	318	316L
321	S32100	1.4541	347	318	308 / 308L
321H	S32109	1.4941	347	318	308 / 308L
347	S34700	1.455	347	318	308 / 308L
347H	S34709	--	347	318	308 / 308L
348	S34800	--	347	318	308 / 308L
384	S38400	--	309L / 309Mo		312 (Weldall)
--					

Welding of Stainless Steel

Ferritic Stainless Steels:

Ferritic Stainless Steels can be welded under strict precautions using all standard arc welding processes. They can be joined with welding consumables which match or near match tha base metal or with austenitic welding consumables,for example Satincrome 308L-17 & 316L-17 electrodes or autocraft 308LSi & 316LSi GMAW wire. During welding, ferritic stainless steel grades can suffer a loss of ducility due to grain growth, martensite formation and carbide presipitation. To achieve good welds,in thicker sections, it is often necessary to preheat the work to ≈100-120°C and minimise the heat input during welding welding. To dissolve or modify carbides in the Heat Affected Zone (HAZ) and reduce welding stresses, post-weld heat tretment to 750-850°C for 30-60 minutes is necessary. This heat treatment will improve the ductility, toughness and corrosion resistance of the Heat Affected Zone.

Ferritic Stainless Steel Grades - Welding Consumable Selection Guide.

Stainless Steel Grade			Welding Consumable Type		
AISI No:	UNS No:	Werkstoffe No:	1st Choice	2nd Choice	3rd Choice
405	S40500	1.4002	430	309L / 309Mo	308
409	S40900	1.4512	309 / 309Mo	312 (Weldall)	--
429	S42900	1.4001	430	308 / 308L	309L / 309Mo
430	S43000	1.4016	430	308 / 308L	309L / 309Mo
430F	S43020	1.4104	430	308 / 308L	309L / 309Mo
430FSe	S43023	--	430	308 / 308L	309L / 309Mo
434	S43400	1.4113	430	308 / 308L	309L / 309Mo
436	S43500	--	430	308 / 308L	309L / 309Mo
442	S44200	--	316L	318	309L / 309Mo
444	S44400	1.4521	316L	318	309L / 309Mo
446	S44600	1.4762	308 / 308L	309L / 309Mo	310

Welding of Stainless Steel

Martensitic Stainless Steels:

Martensitic Stainless Steel are difficult to weld successfully due to the formation of hard and brittle martensite in the Heat Affected Zone (HAZ) of the joint. To reduce the affects of martensite formation, adequate control over pre-heat, interpass temperatures and heat input are essential. Depending on the carbon of the particular martensitic steel, preheat temperatures of between 100-300°C are commonly recommended to avoid cracking. Interpass welding, an interpass temperature between the martensite start and finish temperatures (Ms and Mf) will minimise crack sensitivity by allowing each subsequent weld pass to be tempered. Post Weld-Heat Treatment (PWHT) is also carried out to improve machanical properties and reduce welding stresses. For complicated joint configurations PWHT is commenced one the fully welded joint has cooled to just under the martensite start temperature (≈130 - 150°C). This is done to ensure the complete transformation of sustenite to martensite before PWHT.

Martensitic Stainless Steel Grades - Welding Consumable Selection Guide.

Stainless Steel Grade			Welding Consumable Type		
AISI No:	UNS No:	Werkstoffe No:	1st Choice	2nd Choice	3rd Choice
403	S40300	1.4	410	309L / 309Mo	310
410	S41000	1.4006	410	309L / 309Mo	310
414	S41400	--	410	309L / 309Mo	310
415	S41500	1.4313	410	309L / 309Mo	310
416	S41600	--	410	309L / 309Mo	310
416Se	S41623	--	410	309L / 309Mo	310
420	S42000	--	410	309L / 309Mo	310
431	S43100	1.4057	430	308L / 308	309
440A	S44002	--	312(Weldall)	309L / 309Mo	--
440B	S44003	--	312(Weldall)	309L / 309Mo	--
440C	S44004	--	312(Weldall)	309L / 309Mo	--

Duplex Stainless Steels

Duplex stainless steels consist of two microstructure phrases, ferrite and are also refered to as Ferritic-Austenitic stainless steel A typical duplex microstructure consists of approximately 50% ferrite and 50% austenite.

Duplex stainless steels are readily welded with precautions using all common arc welding processes. Careful attention must be given the heat input and consumable selection to prevent the formation of excessive ferrite levels in both the base matal and weld metal, which can reduce joint toughness and corrosion resistance.

The main grades of duplex stainless steess used in industry today are listed below. These alloys can be classified into two (2) main groups:

Duplex Stainless Steels
=S32900 (329), S39205 (2205) and S39230 (2304)

Super Duplex Stainless Steels
=S39553, S39275 (2507) and S39276 (Zeron 100).

Welding Consumables for duplex stainless steels contain Nitrogen(a strong austenite stabiliser) as an alloying element, which helps to achieve the correct balance of austenite and ferrite in the weld deposit microstructure. In addition to welding consumable selection, careful attention must also be given to heat input and interpass temperature to promote the desired balance of ferrite and austenite in the weld and surrounding Heat Affected Zone (HAZ) of the base material. If the base metal and weld metal ferrite levels are controlled to 25-50% (FN 30-70) then a good combination of strength, toughness and corrosion resistance will be achieved in the welded joint.

Heat Input

When the weld pool solidifies, the weld metal consists of 100% ferrite which begins to transform to austenite upon cooling. If the correct heat input is used the resultant cooling rate will promote the formation of an even distribution of the ferrite and austenite (≈50:50) in the weld deposit and Heat Affected Zone (HAZ)

Duplex Stainless Steels cont.

Generally heat input should be limited to between 0.6-2.6 kJ/mm. When a welding process with less than 0.6kJ/mm. Heat input is used (as in automatic GMAW),preheating up to 150 o C maximum may be required to reduce the cooling rate and increase austenite in the weld and the HAZ.

$$\text{Heat Input (kJ/mm)} = \frac{\text{Volts x Amps x 60}}{\text{Travel Speed (mm/min) x 100}}$$

Interpass Temperature Control

Interpass temperature should be limited to between 75-150 °C

Welding of Stainless Steel

Preheat

On thicknesses below 6mm no preheat is required. For heavier sections or for welds under high restraint preheat may be used to minimise the risk of weld cracking. When a welding process with less than 0.6kJ/mm heat input is used, preheating to between 50-200 °C is helpful in reducing the cooling rate and increasing austenite in the weld and the HAZ. If the air temperature is below 15 °C preheat of ≈50 °C should be used.

Correct Welding Consumables and Shielding Gas:

Always use the correct welding electrode, wire or rod (refer to the welding consumable selection guide shown below) For GTAW (TIG) welding do not weld without a filler rod unless using the correct nitrogen content shielding gas. Always use an inert (nitrogen containing) backing gas when completing root runs. Consult your local gas supplier for detailed information.